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Description

Field of The Invention

This invention relates to surgical devices in general, and more particularly to suture anchors of the sort adapted to anchor one end of a piece of conventional suture in bone, and installation tools for deploying the same.

Background of The Invention

In U.S. Patent No. 4,898,156, there is disclosed a variety of suture anchors of the sort adapted to anchor one end of a piece of conventional suture in bone, and there is disclosed several suture anchor installation tools for deploying such suture anchors in bone.

Looking now at Fig. 1, there is shown one of the suture anchors disclosed in U.S. Patent No. 4,898,156. This suture anchor, identified generally by the numeral 105, comprises a coupling member 110 and a barb 115.

Coupling member 110 comprises a piece of 6Al4V titanium alloy having a first end surface 120 and a second end surface 125. First end surface 120 is disposed at an angle of approximately 30 degrees to the coupling member's longitudinal axis, and second end surface 125 is disposed at a right angle to the coupling member's longitudinal axis, as shown. Coupling member 110 has a blind hole 130 opening on second end surface 125, and a bore 135 extending at an angle between the coupling member's side wall and its bottom end surface 120, as shown. Bore 135 extends at a right angle to the coupling member's bottom end surface 120. In the case of a suture anchor adapted to anchor a No. 0 suture (i.e., a suture having a diameter of approximately 0.036 cm [0.014 inch]), coupling member 110 preferably has a length of approximately 0.41 cm (0.160 inch) and a diameter of approximately 0.135 cm (0.053 inch), blind hole 130 has a depth of approximately 0.178 cm (0.070 inch) and a diameter of approximately 0.071 cm (0.028 inch), and bore 135 has a diameter of approximately 0.071 cm (0.028 inch).

Barb 115 comprises a curved length of nickel titanium alloy having a first end 140 and a second end 145. In the case of a suture anchor adapted to anchor a No. 0 suture barb 115 preferably has a diameter of approximately 0.066 cm (0.026 inch) and, in its unrestrained state, comprises an arc of approximately 135 degrees of a loop approximately 0.664 cm (0.250 inch) in diameter (when measured to the inside of the loop). Barb 115 is attached to the coupling member by fitting the barb's first end 140 into the coupling member's blind hole 130, whereby the barb's second end 145 extends upward and outward from the coupling member. Coupling member 110 is then crimped inward at one or more points as shown at 150 to lock barb 115 to the coupling member. Barb 115 is made of such a nickel titanium alloy that it is capable of being elastically deformed to a substantially straight length when desired (i.e., so that the barb's second end 145 is aligned with its first end 140, as well as with the opposite ends of the coupling member). By way of example, barb 115 may be made out of binary nitinol such as that sold by Furukawa of Japan and Raychem Corporation of Menlo Park, California, or it might be made out of ternary nitinol such as that sold by Raychem Corporation and described in U.S. Patent No. 4,505,767 (Quinn).

Looking next at Fig. 2, there is shown one of the suture anchor installation tools disclosed in the above-identified U.S. Patent No. 4,898,156 This suture anchor installation tool, identified generally by the numeral 205, may be used to deploy the suture anchor shown in Fig. 1. Installation tool 205 comprises a hollow sheath or cannula 210, a hollow loader or inserter 215 and a solid (or hollow) plunger 220.

Hollow sheath 210 terminates in a flat annular surface 225 at its front end and a flat annular surface 230 at its rear end. Surfaces 225 and 230 are disposed at an angle substantially perpendicular to the longitudinal axis of sheath 210. Sheath 210 has an axial bore 235 extending between its front and rear surfaces 225 and 230. Sheath 210 includes a disk-like finger grip 240 which is affixed to the rear end of the outer sheath member and includes a flat surface 245 which is coplanar with the sheath member's rear surface 230. In the case of an installation tool adapted to deploy a suture anchor for anchoring a No. 0 suture, sheath 210 preferably has an outer diameter (i.e., forward of finger grip 240) of approximately 0.211 cm (0.083 inch), an inner diameter of approximately 0.180 cm (0.071 inch), and a length of approximately 10.16 cm (4.0 inches).

Hollow loader 215 terminates in a flat annular surface 250 at its front end and a flat annular surface 255 at its rear end. Surfaces 250 and 255 are disposed at an angle substantially perpendicular to the longitudinal axis of loader 215. Loader 215 has an axial bore 260 extending between its front surface 250 and its rear surface 255. Loader 215 includes a disk-like finger grip 265 which is attached to the rear end of the loader member and includes a flat surface 270 that is coplanar with the loader's rear surface 255.

Loader 215 is sized so that it will make a close sliding fit within bore 235 of sheath 210, as will hereinafter be described in further detail, and also so that its leading tip 250 will not protrude from the front end of sheath member 210 when the loader is inserted into the sheath's axial bore 235 and the loader's finger grip 265 is in engagement with the sheath's rear surface 230, as will hereinafter be described in further detail. In the case of an installation tool adapted to deploy a suture anchor for anchoring a No. 0 suture, loader 215 preferably has an outer diameter (i.e., forward of finger grip 265) of approximately 0.165 cm (0.065 inch), an inner diameter of approximately 0.119 cm (0.047 inch), and a length of approximately 10.49 cm (4.13 inches).

Plunger 220 includes a solid (or hollow) body section 275 and a head section 280. Body section 275 has a round cross-section and terminates in a front surface 285. Plunger 220 is sized so that its body section 275 will make a close sliding fit within bore 260 of loader 215 and also so that its leading tip 285 will protrude from the front end of the loader member a short distance when the plunger's head section 280 is in engagement with the loader member's rear surface 270, as will hereinafter be described in further detail. In the case of an installation tool adapted to deploy a suture anchor for anchoring a No. 0 suture, plunger 220 preferably has a diameter of approximately 0.119 cm (0.047 inch) forward of head section 280, and a length of approximately 10.97 cm (4.32 inches), as will hereinafter be described in further detail.

Installation tool 205 is intended to be utilized as follows. Looking next at Fig. 3, suture anchor 105 is loaded into the top end of sheath member 210 so that the suture anchor's coupling member 110 resides inside the sheath's axial bore 235 and the suture anchor's barb 115 extends above finger grip 240 of the sheath member. Looking next at Fig. 4, the front end 250 of loader 215 is then slipped over the free end of the suture anchor's barb 115 so that the free end of the barb extends into the loader member's axial bore 260. Then loader member 215 is (a) forced into coaxial alignment with outer sheath member 210, thereby straightening out barb 115 in the process, and (b) pushed into the interior of sheath member 210, carrying the suture anchor downward within the sheath member as it goes. In order to assure that barb 115 of suture anchor 105 is contained completely within loader 215 such that suture anchor loader surface 250 contacts suture anchor surface 125, the sheath's bottom surface 225 is rested against a stationary surface 305 (see Fig. 5) while suture anchor loader 215 is brought downward into direct contact with the suture anchor's rear surface 125. Sheath member 210 and loader member 215 are carefully sized relative to one another (and relative to suture anchor 105) so that when the loader member's finger grip 265 is thereafter brought into contact with the sheath member's top surface 245, the suture anchor will protrude slightly from the bottom end of the sheath member, as shown in Fig. 6. More specifically, as seen in Figs. 7 and 8, sheath member 210 and loader member 215 are sized relative to one another (and relative to suture anchor 105) so that both ends of the suture anchor's diagonal bore 135 will be exposed to view when the loader member's finger grip 265 is brought into contact with the sheath member's top surface 245. With the suture anchor so held by the installation tool, a conventional suture 405 may then be easily attached to the suture anchor by passing the suture through the anchor's diagonal bore 135 and tying a knot 410 at the end of the suture which can then bear against the bottom end 120 of the suture anchor's coupling member, as shown in Figs. 7 and 8.

Once the suture has been attached to the suture anchor in the foregoing manner, plunger member 220 may then be inserted into the loader member's internal bore 260 (see Fig. 9) and pressed downward until its bottom tip 285 contacts the suture anchor barb contained in the loader member's bore 260. By appropriately sizing the respective members involved, the head section 280 of the plunger member will remain slightly above finger grip 265 of loader member 215 when the plunger member's tip 285 engages barb 115 of suture anchor 105.

Thereafter, when the installation tool is actually to deploy the suture anchor (and its attached suture) into bone, the tip of the installation tool is inserted into a hole 505 formed in a bone 510 until the suture anchor rests on the bone surface 515 (see Fig. 10), and then head section 280 of plunger member 220 is held stationary while finger grip 240 of sheath member 210 is pulled upward so that the loader's flat surface 270 engages the underside of the plunger's head section 280, thereby ejecting the suture anchor 105 (and its attached suture 405) out of the installation tool and into the bone, as shown in Figs. 10 and 11.

Complete details regarding the construction and use of suture anchor 105 and installation tool 205 are provided in the above-identified U.S. Patent Nc. 4,898,156 which is incorporated herein by reference; the foregoing description is provided merely for convenient reference in understanding the present invention.

With the three-element installation tool 205 described above, a hole slightly larger in size than the combined diameters of the outer sheath member 210 and the suture 405 must be drilled in the bone. For example, with a suture anchor for anchoring a No. 0 suture, where the suture anchor's coupling member 110 has a diameter of approximately 0.135 cm (0.053 inch), suture 405 has a diameter of approximately 0.036 cm (0.014 inch), and outer sheath 210 has a diameter of approximately 0.211 cm (0.083 inch), a hole

approximately 0.249 cm (0.098 inch) in diameter must be drilled in the bone. In the case of a suture anchor for anchoring a No. 2 suture, where the suture anchor's coupling member 110 has a diameter of approximately 0.155 cm (0.061 inch), suture 405 has a diameter of approximately 0.051 cm (0.020 inch), and outer sheath 210 has a diameter of approximately 0.241 cm (0.095 inch), a hole approximately 0.295 cm (0.116 inch) in diameter must be drilled in the bone.

A summary table of such sizing is given below:

Table 1

	Suture Size:			
	No. 0		No. 2	
	cm	inches	inches	cm
Suture Anchor Dia.	0.135	0.053	0.061	0.155
Sheath Diameter	0.211	0.083	0.095	0.241
Suture Diameter	0.036	0.014	0.020	0.051
		-----	-----	
Sheath + Suture Dia.	0.246	0.097	0.115	0.292
Drill Diameter	0.249	0.098	0.116	0.295
(Drill hole) -(Suture Anchor)	0.114	0.045	0.055	0.140

Unfortunately, while the three-element installation tool 205 described above is known to work, it is also believed to suffer from a number of disadvantages.

For one thing, it will be seen from Table 1 above that the three-element installation tool 205 takes up a substantial amount of room in the bone hole relative to the diameter of the suture anchor. More specifically, as seen in Table 1 above, the suture anchor for anchoring a No. 0 suture has a coupling member diameter of approximately 0.135 cm (0.053 inch), yet it requires a drilled hole of approximately 0.249 cm (0.098 inch) to accommodate the suture anchor when it is set by installation tool 205. Therefore, the suture anchor's barb must essentially take up the difference between the 0.135 cm (0.053 inch) coupling member and the 0.249 cm (0.098 inch) hole when the suture anchor is set in the hole. Thus, the barb must expand approximately 0.114 cm (0.045 inch) for the suture anchor used to anchor a No. 0 suture. Similarly, as seen in Table 1 above, the suture anchor for anchoring a No. 2 suture has a coupling member diameter of approximately 0.155 cm (0.061 inch), yet it requires a drilled hole of approximately 0.295 cm (0.116 inch) to accommodate the suture anchor when it is set by installation tool 205. Therefore, the barb must essentially take up the difference between the 0.155 cm (0.061 inch) coupling member and the 0.295 cm (0.116 inch) hole when the suture anchor is set in the hole. Thus, the barb must expand approximately 0.140 cm (0.055 inch) for the suture anchor used to anchor a No. 2 suture. Inasmuch as the barb loses force as it returns closer and closer to its original curved shape from its constrained straight shape (e.g. much like a spring), the larger the difference existing between the bone hole diameter and the suture anchor body, the smaller the force applied to the side wall of the bone by the suture anchor's barb when the suture anchor is set in the bone, and hence the weaker the attachment of the suture anchor to the bone. Accordingly, a fit such as that mandated by the use of the three-element installation tool 205 could possibly lead to inconsistent anchoring of the suture in the bone.

Another disadvantage of the three-element installation tool 205 described above is that the outer sheath 210 and loader member 215 can be preloaded with the suture anchor (in the manner shown in Figs. 5 and 6) but, if it is then left for a substantial amount of time between loading and use, the barb can lose its resiliency and relax over time, so that when the suture anchor is thereafter used, its barb may not contact the bone wall with the same force that it would have if the suture anchor had been used immediately after loading the suture anchor into sheath 210 and loader 215. Accordingly, preloading accompanied by delayed use can possibly lead to inconsistent and unsatisfactory anchoring of the bone anchor in the bone.

Objects Of The Invention

A principal object of the present invention is to provide a novel suture anchor configuration which facilitates insertion of the suture anchor.

Another object of the present invention is to provide a suture anchor and suture anchor installation tool which improve upon the suture anchor and the three-element installation tool of the above-identified U.S.

Patent No. 4,898,156.

According to the present invention there is provided a suture anchor for anchoring a portion of a length of suture in bone, the suture anchor comprising:

(a) a coupling member having a longitudinal axis, a lower end and an upper end:

(b) at least one barb, each barb having a first end and a second end, being curved in its normal unstressed state, being capable of being elastically deformed to a substantially straight configuration, and being attached to the upper end of the coupling member so that the second end of each barb is substantially displaced from the coupling member when the barb is in its normal unstressed state, but is capable of being aligned with the coupling member when the barb is deformed to a substantially straight length; and

(c) attachment means for attaching a portion of the length of suture to the coupling member;

the suture anchor being characterized in that the coupling member defines a lower portion extending upwardly from the lower end, a reduced upper portion extending downwardly from the upper end, and an upwardly facing shoulder formed at the junction of the upper portion and the lower portion.

Also according to the present invention there is provided a suture and suture anchor assembly for attaching objects to bone, said suture and suture anchor assembly comprising:

(a) a suture having a first end and a second end;

(b) a coupling member having a longitudinal axis, a lower end and an upper end;

(c) at least one barb, each barb having a first end and a second end, being curved in its normal unstressed state, being capable of being elastically deformed to a substantially straight configuration, and being attached to the upper end of the coupling member so that the second end of each barb is substantially displaced from the coupling member when the barb is in its normal unstressed state, but is capable of being aligned with the coupling member when the barb is deformed to a substantially straight length;

wherein a portion of the suture is attached to the coupling member so that at least one end of the suture is free for use in attaching objects to bone when the suture and suture anchor assembly is anchored in bone;

the suture anchor being characterized in that the coupling member defines a lower portion extending upwardly from the lower end, a reduced upper portion extending downwardly from the upper end, and an upwardly facing shoulder formed at the junction of the upper portion and the lower portion.

Further in accordance with the present invention there is provided a system for attaching objects to bone, the system comprising:

a suture anchor comprising:

(a) a coupling member having a first longitudinal axis, a lower end and an upper end;

(b) at least one barb, each barb having a first end and a second end, being curved in its normal unstressed state, being capable of being elastically deformed to a substantially straight configuration, and being attached to the upper end of the coupling member so that the second end of each barb is substantially displaced from the coupling member when the barb is in its normal unstressed state, but is capable of being aligned with the coupling member when the barb is deformed to a substantially straight length; and

(c) attachment means for attaching a portion of the length of suture to the coupling member; and

an installation tool comprising:

an elongated member having a second longitudinal axis, a first end, a second end , and a slot extending from the second end toward the first end, the elongated member defining an axial cavity extending into the second end;

the system being characterized in that

(i) in the suture anchor the coupling member defines a lower portion extending upwardly from the lower end, a reduced upper portion extending downwardly from the upper end, and an upwardly facing shoulder formed at the junction of the upper portion and the lower portion, and

(ii) in the installation tool the axial cavity is sized to accommodate at least the reduced upper portion of the coupling member, the elongated member further comprises stop means for preventing the suture anchor from moving in a first axial direction relative to the elongated member when the reduced upper portion is received in the axial cavity, and the slot is sized to accommodate the barb in both the unstressed and stressed configurations thereof when the reduced upper portion of the coupling member is received in the axial cavity.

Brief Description Of The Drawings

Still other objects and features of the present invention will be more fully described or rendered obvious in the following detailed description of the invention, which is to be considered together with the accompanying drawings wherein like numbers refer to like parts and further wherein:

Fig. 1 is a side view in elevation of a prior art suture anchor disclosed in the above-identified U.S. Patent Application Serial No. 051,367;

Fig. 2 is a side view in elevation, in section, showing a prior art suture anchor installation tool disclosed in U.S. Patent Application Serial No. 051,367;

Figs. 3-11 are a series of views showing the suture anchor of Fig. 1 being deployed into a bone hole using the suture anchor installation tool of Fig. 2;

Fig. 12 is a side view in elevation, partly in section, showing the preferred embodiment of the suture anchor installation tool which constitutes the present invention;

Fig. 13 is an end view in elevation showing the distal end of the suture anchor installation tool of Fig. 12;

Fig. 14A is a side view in elevation showing the suture being attached to the suture anchor remote from the installation tool;

Fig. 14B is a perspective view showing the suture and suture anchor of Fig. 14A, the installation tool of Figs. 12 and 13, and a target bone which is to receive the suture anchor, all in exploded relation to one another;

Fig. 15 is an enlarged partial perspective view showing the suture anchor of Fig. 1 being loaded onto the distal end of the suture anchor installation tool of Figs. 12 and 13;

Fig. 16 is a perspective view showing the suture anchor of Fig. 1 being loaded onto the distal end of the suture anchor installation tool of Figs. 12 and 13;

Fig. 17 is a side view in elevation showing the suture anchor of Fig. 1 and the suture anchor installation tool of Figs. 12 and 13 as the suture anchor is being introduced into a hole formed in bone;

Fig. 18 is a side view in elevation showing the suture anchor of Fig. 1 remaining in the hole formed in the bone as the suture anchor installation tool is withdrawn;

Fig. 19 is a partial perspective view showing a second embodiment of the suture anchor installation tool;

Fig. 20 is a partial side elevation showing a third embodiment of the suture anchor installation tool receiving a suture anchor;

Fig. 21A is a partial perspective view showing a fourth embodiment of the suture anchor installation tool;

Fig. 21B is a partial side elevation showing a fifth embodiment of the suture anchor installation tool;

Fig. 22 is a partial perspective view showing a sixth embodiment of the suture anchor installation tool;

Fig. 23 is a side view in elevation showing a novel drill for forming the hole in the bone which is to receive the suture anchor;

Fig. 24 is a side view in elevation showing the novel drill of Fig. 19 in the process of forming a hole in bone;

Fig. 25 is a side view in elevation, partly in section, showing the suture anchor installation tool of Fig. 12 and a modified form of suture anchor, in exploded relation; and

Fig. 26 is a side view in elevation showing the modified suture anchor of Fig. 25 loaded onto the suture anchor installation tool of Fig. 12.

Detailed Description Of The Invention

Looking now at Figs. 12 and 13, there is shown a suture anchor installation tool 605 which constitutes the preferred embodiment of the present invention. Installation tool 605 comprises a hollow cannula 610 having a distal end 615 terminating in a flat end surface 620 and a rear end 625 terminating in a flat disk or knob 630. A longitudinally-extending slot 635 is formed in the side wall of cannula 610. Slot 635 begins at the cannula's distal end surface 620 and terminates in a rear surface 640.

Installation tool 605 is adapted to be used to install a suture anchor such as the suture anchor 105 previously described, and to this end it is important that installation tool 605 be dimensioned in accordance with the dimensions of the actual suture anchor being deployed by the tool. Specifically, it is important that suture anchor installation tool 605 be sized so that (a) its cannula 610 has an outer diameter smaller than, equal to or just slightly larger than the outer diameter of the suture anchor's coupling member 110 so that the smallest possible hole may be formed in the bone which is to receive the bone anchor, (b) its cannula 610 has an internal diameter smaller than the outer diameter of the suture anchor's coupling member 110, so that the coupling member will not be able to slip inside the cannula, (c) its slot 635 has a width equal to or just slightly larger than the diameter of the suture anchor's barb 115, so that the barb will fit snugly

between the walls of cannula 610 which define its slot 635, as will hereinafter be described in further detail, and (d) its slot 635 has a length sufficient to accommodate the suture anchor's barb 115 when the barb is bent backwards into the cannula during deployment of the suture anchor, as will hereinafter be described in further detail.

For example, in the case where suture anchor 105 is to be used to anchor a No. 0 suture, so that the suture anchor has the dimensions identified above, cannula 610 preferably has an inner diameter of approximately 0.127 cm (0.050 inch) and an outer diameter of approximately 0.147 cm (0.058 inch), slot 635 has a length (i.e., when measured from flat end surface 620 to slot rear surface 640) of approximately 0.940 cm (0.370 inch) and a width of approximately 0.079 cm (0.031 inch). In the case where suture anchor 105 is to be used to anchor a No. 2 suture, the same installation tool may be used, since the suture anchor used in conjunction with a No. 2 suture will have the same size barb and an even wider diameter coupling member than the suture anchor used in conjunction with a No. 0 suture. Preferably, suture anchor installation tool 605 has an overall length, when measured from distal end 620 to the rear of disk 630, of approximately 10.16 cm (4.0 inches).

In use, a suture is first attached to suture anchor 105, then the suture anchor is attached to the distal end of installation tool 605, and then the suture anchor is deployed into a hole formed in the bone using installation tool 605.

More specifically, and looking now at Figs. 14A, 14B and 15, the suture is first attached to the suture anchor in the manner shown in Fig. 14A, i.e., by passing the suture through the suture anchor's bore 135 and then tying a knot 410 at the bottom end of the suture so that the knot seats against face 120 of suture anchor 105. Suture anchor 105 is then attached to the distal end of the installation tool by fitting the suture anchor's barb 115 into the installation tool's slot 635 and pressing the top surface 125 of the suture anchor flush against the installation tool's bottom surface 620. It will be appreciated that in view of the relative dimensioning of the suture anchor and the installation tool, coupling member 110 of the suture anchor is unable to enter the interior of cannula 610, and barb 115 will make a snug fit in cannula slot 635, the fit being snug enough to hold the suture anchor attached to the bottom end of the cannula.

The suture anchor is then ready to be deployed in a hole 505 formed in a bone 510 (see Fig. 16). It is to be appreciated that the hole formed in the bone is carefully sized according to the dimensions of the suture and suture anchor being deployed in the bone. For example, in the cage of a No. 0 suture anchor, the hole formed in bone 510 is sized so as to have a diameter of approximately 0.183 cm (0.072 inch) and a depth of approximately 1.79 cm (0.70 inches).

Looking next at Figs. 17 and 18, the suture anchor is then deployed in the bone hole by pressing the distal end of the cannula down into the predrilled hole 505 in bone 510 until the assembly bottoms out on bone surface 515. As the distal end of the cannula forces the suture anchor down into the bone, the suture anchor's barb 115 engages the side wall of the bone, forcing the barb to retract inwards, into the cannula slot, so that the suture anchor installation tool (and the suture anchor and the suture carried by the suture anchor) can enter bone hole 505. When the bottom of the bone anchor bottoms out in bone hole 505 (see Fig. 18), and the cannula is thereafter withdrawn, the engagement of the suture anchor's barb with the bone wall causes the suture anchor to separate from the cannula, leaving the suture anchor (and its attached suture) securely anchored in the bone.

By using the installation tool 605 just described, a hole only slightly wider than the combined diameters of the cannula 610 and the suture 405 may be drilled in the bone. For example, where a No. 0 suture is to be attached to the bone using a bone anchor 105 and an installation tool 605 of the dimensions indicated above, a hole only approximately 0.183 cm (0.072 inch) in diameter must be drilled in the bone; where a No. 2 suture is to be attached to the bone using an appropriately sized bone anchor 105 and an appropriately sized installation tool 605, a hole only approximately 0.218 cm (0.086 inch) in diameter must be drilled in the bone.

A summary table of such sizing is given below:

Table 2

	Suture Size:			
	No. 0		No. 2	
	cm	inches	inches	cm
Suture Anchor Dia.	0.135	0.053	0.061	0.155
Cannula Diameter	0.147	0.058	0.058	0.147
Suture Diameter	0.036	0.014	0.020	0.051
		-----	-----	
Cannula + Suture Dia.	0.170	0.067	0.081	0.206
Drill Diameter	0.183	0.072	0.086	0.218
(Drill hole) -(Suture Anchor)	0.05	0.019	0.025	0.063

A comparison of Table 2 with Table 1 shows that significantly smaller bone holes may be used when using the installation tool of Figs. 12 and 13 in place of the three-element installation tool of Fig. 2; as a result, less expansion of barb 115 is required to fix the suture anchor in the bone and a tighter attachment of the suture anchor to the bone results.

Thus, for example, it is anticipated that installation tool 605 could be formed out of a substantially solid rod rather than a hollow cannula; in this case, installation tool 605A (see Fig. 19) would comprise a solid rod 610A having a slot 635A formed therein. Rod 610A would have the same outer diameter as the cannula 610 previously described. It will be appreciated that installation tool 605A functions in exactly the same manner, and provides substantially the same advantages, as the installation tool 605 previously described.

It is also anticipated that some or all of the suture anchor's coupling member 110 could be received within a portion of the installation tool to help hold the suture anchor aligned with the installation tool during insertion of the suture anchor into the bone. Thus, for example, a modified form of installation tool 705 is shown in Figure 20. Installation tool 705 is identical to the installation tool 605 previously described, except that the cannula 710 is sized to accept a portion of the coupling member 110 of the suture anchor 105. More specifically, cannula 710 has a slightly larger outer diameter than the cannula 610 previously described, and it includes a counterbore 745 which opens on the cannula's distal surface 720 and which terminates in an internal shoulder 750. Shoulder 750 is positioned at a sufficient depth to allow a portion of the suture anchor's coupling member to be received within the cannula's counterbore 745, with the suture anchor's suture-receiving hole still being completely exposed. Preferably counterbore 745 and shoulder 750 are created by relieving a thick-walled hypodermic tubing to the desired depth.

In the case where suture anchor 105 is to be used to anchor a No. 0 suture, so that the suture anchor has the dimension identified above, cannula 710 preferably has an inner diameter or approximately 0.137 cm (0.054 inch) and an outer diameter of approximately 0.165 cm (0.065 inch), slot 735 has a length (i.e., when measured from flat end surface 720 to the slot rear surface 740) of approximately 0.940 cm (0.370 inch) and a width of 0.079 cm (0.031 inch). The cavity which accepts the suture anchor has a length (i.e., when measured from flat end surface 720 to stop 750) of approximately 0.152 cm (0.060 inch).

In the case where suture anchor 105 is to be used to anchor a No. 2 suture, so that the suture anchor has the dimension identified above, cannula 710 preferably has an inner diameter of approximately 0.158 cm (0.062 inches) and an outer diameter of approximately 0.183 cm (0.072 inches), slot 735 has a length (i.e., when measured from flat end surface 720 to the slot rear surface 740) of approximately 0.940 cm (0.370 inch) and a width of approximately 0.079 cm (0.031 inch). The cavity which accepts the suture anchor has a length (i.e., when measured from flat end surface 710 to stop 750) of approximately 0.152 cm (0.060 inch).

Preferably the suture anchor installation tool 705 has an overall length, when measured from distal end 720 to the rear of its top end, of approximately 10.16 cm (4.0 inches).

Looking next at Fig. 21A, there is shown a substantially "solid" installation tool 705A which is adapted to receive a portion of the suture anchor's coupling member in the installation tool's distal end. To this end, installation tool 705A comprises a solid rod 710A having a slot 735A and a blind hole 745A formed therein. During use, the upper end of the suture anchor's coupling member is received in blind hole 745A. Blind hole 745A is sized to have a depth such that the suture anchor's suture-receiving hole will remain exposed when the coupling member is attached to the installation tool. Rod 710A is intended to have the same outer diameter as the cannula 710 previously described.

Looking next at Fig. 21B, there is shown yet another form of the invention. Installation tool 705B is identical to the installation tool 705 previously described, except that the hollow cannula 710B has an internal diameter as large as the diameter of the previously described counterbore 745, in order that the entire suture anchor will be received inside cannula 710A. No counterbore 745 or shoulder 750 is provided; instead, the cannula is crimped inward at 755B at one or more locations to form a stop for engaging the upper surface of the coupling member. Preferably crimps 755B are placed sufficiently far up along cannula 710B so that the entire length of the suture anchor's coupling member may be received within the cannula; in this case, a slot 736B is formed in the cannula, diametrically opposed from the barb-receiving slot 735B, to allow suture 405B to pass through the cannula's side wall. Cannula 710B is intended to have the same outer diameter as the cannula 710 previously described.

The installation tools shown in Figs. 20, 21A and 21B all have an outer diameter which is greater than the outer diameter of the installation tools shown in Figs. 12 and 19; nonetheless, smaller bone holes can still be used when using the installation tools of Figs. 20, 21A and 21B than when using the three-element installation tool of Fig. 2. More specifically, a summary table of the sizing for the tools of Figs. 20, 21A and 21B is given below:

TABLE 3

	Suture Sizes			
	No. O		No. 2	
	cm	inches	inches	cm
Suture Anchor (SA) OD	0.135	.053	.061	0.155
Inserter OD	0.165	.065	.072	0.183
Inserter ID	0.137	.054	.062	0.158
Suture Diameter	0.036	.014	.020	0.051
		-----	-----	
(Inserter OD) + (Suture Diameter)	0.20	.079	.092	0.234
Drill Diameter	0.20	.079	.094	0.239
(Drill Hole) -(SA Diameter)	0.07	.026	.033	0.084

A comparison of Table 3 and Table 2 with Table 1 shows that significantly smaller bone holes can be used when using the installation tools of Figures 12 and 19, or Figures 20, 21A and 21B, in place of the three-element installation tool of Figure 2. In both designs, less expansion of barb 115 is required to fix the suture anchor in the bone.

Furthermore, it is anticipated that installation tools 605, 605A, 705, 705A and/or 705B could be provided with a plurality of slots 635, 635A, 735, 735A and 735B, respectively, for situations where the installation tool is to be used to deploy a suture anchor 105B of the sort having two or more barbs 115B. Fig. 22 illustrates a suture anchor installation tool 605B which may be used to install a suture anchor 105B (having three barbs 115B) in bone.

Yet another modification relates to the method of utilizing the present invention. More specifically, while in all of the foregoing embodiments it was described that the suture is attached to the suture anchor prior to attaching the suture anchor to the installation tool, it is also anticipated that the suture could be attached to the suture anchor after the suture anchor is attached to the installation tool.

Looking next at Figs. 23 and 24, there is also shown a novel drill 805 for forming the hole 505 in bone 510 which is to receive the suture anchor. Drill 805 comprises a conventional helical drill thread 810 at its distal end. Thread 810 terminates in an inclined frustoconical shoulder 815 which serves as a stop to prevent the drill from penetrating too far into the bone. Shoulder 815 also serves to chamfer bone 510 at 515 as shown so as to minimize chafing of the suture about the top of hole 505.

It is also to be appreciated that the suture anchor's coupling member 110 could be formed out of a material other than 6AL4V titanium alloy, and barb 115 could be formed out of a material other than nickel titanium alloy. For example, coupling member 110 could be formed out of titanium and its alloys, ceramics, plastics, stainless steel and other suitable bio-compatible materials, and barb 115 could be formed out of titanium and its alloys, and stainless steel.

Looking next at Figs. 25 and 26, a modified suture anchor 105A is shown with the suture anchor installation tool 605 previously described.

Suture anchor 105A is identical to the suture anchor 105 previously described, except as will hereinafter be noted. More particularly, the coupling member 110A of suture anchor 105A is slightly longer than the coupling member 110 of suture anchor 105, and comprises a lower portion 111A and an upper portion 112A. Lower portion 111A has a diameter similar to the diameter of coupling member 110, and includes first end surface 120A and suture bore 135A. Upper portion 112A has a reduced diameter that is somewhat less than that of lower portion 111A, and includes second end surface 125A and the blind hole 130A for receiving the first end 140A of barb 115A. A shoulder 113A is formed at the junction of the coupling member's lower portion 111A and its upper portion 112A.

Suture anchor 105A is sized, relative to suture anchor installation tool 605, so that the suture anchor's upper portion 112A can be received in the interior of the tool's cannula 610 (Fig. 26) while the suture anchor's lower portion 111A is positioned in front of the cannula, with the cannula's flat end surface 620 engaging the coupling member's shoulder 113A, and with the suture anchor's barb 115A being accommodated in the tool's slot 635.

In operation, suture anchor 105A and installation tool 605 operate in the manner previously described with respect to suture anchor 105 and tool 605, except that receipt of the suture anchor's upper portion 112A within tool cannula 610, and engagement of the cannula's flat end surface 620 with suture anchor shoulder 113A, yields a more stable engagement between the suture anchor and the suture anchor installation tool during deployment of the suture anchor in bone.

It should also be appreciated that a further advantage obtained by the foregoing construction is that the suture anchor's upper portion can be sized so as to facilitate proper crimping of the coupling member about the barb (i.e., the upper portion 112A can be formed with a diameter more closely corresponding to the diameter of barb 115A, so that there is no excess material to interfere with crimping), while the suture anchor's lower portion 111A (and its associated suture bore 135A) can be sized so as to accommodate the desired suture width. For example, where it is desired to pass a relatively thick suture through suture bore 135A, or even to pass two or more suture strands 405A through suture bore 135A (as shown in Fig. 26), the lower portion 111A of suture anchor 105A can be formed with a greater diameter than it might otherwise be, without interfering with the proper crimping of the coupling member about the barb.

Advantages Of The Invention

Numerous advantages are achieved by utilizing the present invention.

First, a novel suture anchor configuration is disclosed which facilitates insertion of the suture anchor.

Second, a suture anchor and suture anchor installation tool are provided which improve upon the suture anchor and the three-element installation tool of the above-identified U.S. Patent No. 4,898,156.

Claims

1. A suture anchor (105A) for anchoring a portion of a length of suture (405A) in bone, the suture anchor comprising:

   (a) a coupling member (110A) having a longitudinal axis, a lower end (120A) and an upper end (125A);

   (b) at least one barb (115A), each barb having a first end (140A) and a second end (145A), being curved in its normal unstressed state, being capable of being elastically deformed to a substantially straight configuration, and being attached to the upper end (125A) of the coupling member (110A) so that the second end (145A) of each barb (115A) is substantially displaced from the coupling member (110A) when the barb (115A) is in its normal unstressed state, but is capable of being aligned with the coupling member (110A) when the barb (115A) is deformed to a substantially straight length; and

   (c) attachment means (135A) for attaching a portion of the length of suture (405A) to the coupling member (110A);

   the suture anchor (105A) being characterized in that the coupling member (110A) defines a lower portion (111A) extending upwardly from the lower end (120A), a reduced upper portion (112A) extending downwardly from the upper end (125A), and an upwardly facing shoulder (113A) formed at the junction of the upper portion (112A) and the lower portion (111A).

2. A suture anchor according to claim 1, characterized in that the at least one barb (115A) is formed of a nickel titanium alloy.

3. A suture anchor according to claim 1 or claim 2, characterized in that the attachment means (135A) comprises a hole extending transversely through the coupling member (110A).

4. A suture anchor according to claim 3, characterized in that said hole extends at an acute angle to the longitudinal axis of the coupling member (110A).

5. A suture anchor according to claim 3 or claim 4, characterized in that the hole is located intermediate of the upper end and the lower end of the coupling member (110A).

6. A suture anchor according to any one of claims 3 to 5, characterized in that the hole extends through the lower end of the coupling member (110A).

7. A suture anchor according to claim 6, wherein the lower end of the coupling member is disposed at an acute angle to the longitudinal axis.

8. A suture (405A) and suture anchor (105A) assembly for attaching objects to bone, said suture and suture anchor assembly comprising:

(a) a suture (405A) having a first end and a second end;

(b) a coupling member (110A) having a longitudinal axis, a lower end (120A) and an upper end (125A);

(c) at least one barb (115A), each barb having a first end (140A) and a second end (145A), being curved in its normal unstressed state, being capable of being elastically deformed to a substantially straight configuration, and being attached to the upper end (125A) of the coupling member (110A) so that the second end (145A) of each barb (115A) is substantially displaced from the coupling member (110A) when the barb (115A) is in its normal unstressed state, but is capable of being aligned with the coupling member (110A) when the barb (115A) is deformed to a substantially straight length;

wherein a portion of the suture (405A) is attached to the coupling member (110A) so that at least one end of the suture is free for use in attaching objects to bone when the suture and suture anchor assembly is anchored in bone;

the suture anchor (105A) being characterized in that the coupling member (110A) defines a lower portion (111A) extending upwardly from the lower end (120A), a reduced upper portion (112A) extending downwardly from the upper end (125A), and an upwardly facing shoulder (113A) formed at the junction of the upper portion (112A) and the lower portion (111A).

9. A system for attaching objects to bone, the system comprising:

a suture anchor (105A) comprising:

(a) a coupling member (110A) having a first longitudinal axis, a lower end (120A) and an upper end (125A);

(b) at least one barb (115A), each barb having a first end (140A) and a second end (145A), being curved in its normal unstressed state, being capable of being elastically deformed to a substantially straight configuration, and being attached to the upper end (125A) of the coupling member (110A) so that the second end (145A) of each barb (115A) is substantially displaced from the coupling member (110A) when the barb (115A) is in its normal unstressed state, but is capable of being aligned with the coupling member (110A) when the barb (115A) is deformed to a substantially straight length; and

(c) attachment means (135A) for attaching a portion of the length of suture (405A) to the coupling member (110A); and

an installation tool (605) comprising:

an elongated member (610) having a second longitudinal axis, a first end, a second end (620), and a slot (635) extending from the second end toward the first end, the elongated member (610) defining an axial cavity (615) extending into the second end (620);

the system being characterized in that

(i) in the suture anchor (105A) the coupling member (110A) defines a lower portion (111A) extending upwardly from the lower end (120A), a reduced upper portion (112A) extending downwardly from the upper end (125A), and an upwardly facing shoulder (113A) formed at the junction of the upper portion (112A) and the lower portion (111A), and

(ii) in the installation tool the axial cavity is sized to accommodate at least the reduced upper portion of the coupling member, the elongated member further comprises stop means for preventing the suture anchor from moving in a first axial direction relative to the elongated

member when the reduced upper portion is received in the axial cavity, and the slot is sized to accommodate the barb in both the unstressed and stressed configurations thereof when the reduced upper portion of the coupling member is received in the axial cavity.

10. A system according to claim 9, further characterized in that the stop means comprises a surface (620) associated with the second end of the elongated member, the surface being configured to engage the shoulder of the coupling member when the reduced upper portion of the coupling member is received in the axial cavity.

Patentansprüche

1. Nahtmaterialanker (105A) zum Verankern eines Abschnitts einer Länge eines Nahtmaterials (405A) in einem Knochen, wobei der Nahtmaterialanker umfaßt:

(a) ein Kupplungsglied (110A) mit einer longitudinalen Achse, einem unteren Ende (120A) und einem oberen Ende (125A);

(b) mindestens einen Widerhaken (115A), wobei jeder Haken ein erstes Ende (140A) und ein zweites Ende (145A) hat, in seinem normalen entspannten Zustand gekrümmt ist, in der Lage ist, elastisch zu einer im wesentlichen geraden Konfiguration deformiert zu werden, und an dem oberen Ende (125A) des Kupplungsgliedes (110A) befestigt ist, so daß das zweite Ende (145A) jedes Widerhakens (115A) wesentlich von dem Kupplungsglied (110A) verschoben ist, wenn der Widerhaken (115A) sich in seinem normalen entspannten Zustand befindet, aber in der Lage ist, mit dem Kupplungsglied (110A) ausgerichtet zu werden, wenn der Widerhaken (115A) zu einer im wesentlichen geraden Länge deformiert ist; und

(c) Befestigungsmittel (135A) zum Befestigen eines Abschnitts der Länge des Nahtmaterials (405A) an dem Kupplungsglied (110A);

wobei der Nahtmaterialanker (105A) dadurch gekennzeichnet ist, daß das Kupplungsglied (107A) einen unteren Abschnitt (111A), der sich von dem unteren Ende (120A) nach oben erstreckt, einen reduzierten oberen Abschnitt (112A), der sich nach unten von dem oberen Ende (125A) erstreckt, und eine nach oben zeigende Schulter (113A) definiert, die an der Kreuzung des oberen Abschnittes (112A) und des unteren Abschnittes (111A) angeordnet ist.

2. Nahtmaterialanker nach Anspruch 1, dadurch gekennzeichnet, daß der mindestens eine Widerhaken (115A) aus einer Nickel-Titan-Verbindung gebildet ist.

3. Nahtmaterialanker nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß das Befestigungsmittel (135A) ein Loch umfaßt, das sich in transversaler Richtung durch das Kupplungsglied (110A) erstreckt.

4. Nahtmaterialanker nach Anspruch 3, dadurch gekennzeichnet, daß sich das Loch in einem spitzen Winkel zu der longitudinalen Achse des Kupplungsgliedes (110A) erstreckt.

5. Nahtmaterialanker nach Anspruch 3 oder 4, dadurch gekennzeichnet, daß das Loch in der Mitte zwischen dem oberen Ende und dem unteren Ende des Kupplungsgliedes (110A) angeordnet ist.

6. Nahtmaterialanker nach einem der Ansprüche 3 bis 5, dadurch gekennzeichnet, daß sich das Loch durch das untere Ende des Kupplungsgliedes (110A) erstreckt.

7. Nahtmaterialanker nach Anspruch 6, worin das untere Ende des Kupplungsgliedes unter einem spitzen Winkel zu der longitudinalen Achse angeordnet ist.

8. Nahtmaterial-(405A) und Nahtmaterialanker-(105A) Vorrichtung zum Befestigen von Gegenständen an einem Knochen, wobei die Nahtmaterial- und die Nahtankervorrichtung aufweist:

(a) ein Nahtmaterial (405A) mit einem ersten und einem zweiten Ende;

(b) ein Kupplungsglied (110A) mit einer longitudinalen Achse, einem unteren Ende (120A) und einem oberen Ende (125A);

(c) mindestens einen Widerhaken (115A), wobei jeder Widerhaken ein erstes Ende (140A) und ein zweites Ende (145A) hat, in seinem normalen entspannten Zustand gekrümmt ist, in der Lage ist, elastisch zu einer im wesentlichen geraden Konfiguration deformiert zu werden, und so an das obere Ende (125A) des Kupplungsgliedes (110A) befestigt zu werden, daß das zweite Ende (145A) jedes

Widerhakens (115A) wesentlich verschoben von dem Kupplungsglied (110A) ist, wenn der Widerhaken (115A) in seinem normalen entspannten Zustand ist, aber in der Lage ist, mit dem Kupplungsglied (110A) ausgerichtet zu werden, wenn der Widerhaken (115A) zu einer im wesentlichen geraden Länge deformiert wird;

worin ein Abschnitt des Nahtmaterials (405A) an das Kupplungsglied (110A) befestigt ist, so daß mindestens ein Ende des Nahtmaterials frei ist zum Befestigen von Gegenständen an dem Knochen, wenn die Nahtmaterial- und die Nahtankervorrichtung im Knochen verankert ist:

wobei der Nahtmaterialanker (105A) dadurch gekennzeichnet ist, daß das Kupplungsglied (110A) einen unteren Abschnitt (111A), der sich nach oben von dem unteren Ende (120A) erstreckt, einen reduzierten oberen Abschnitt (112A), der sich nach unten von dem oberen Ende (125A) erstreckt, und eine nach oben zeigende Schulter (113A) definiert, die an der Kreuzung des oberen Abschnittes (112A) und des unteren Abschnittes (111A) ausgebildet ist.

9. Ein System zum Befestigen von Gegenständen an einem Knochen, wobei das System umfaßt:

einen Nahtmaterialanker (105A), der aufweist:

(a) ein Kupplungsglied (110A) mit einer ersten longitudinalen Achse, einem unteren Ende (120A) und einem oberen Ende (125A);

(b) mindestens einen Widerhaken (115A), wobei jeder Widerhaken ein erstes Ende (140A) und ein zweites Ende (145A) hat, in seinem normalen entspannten Zustand gekrümmt ist, in der Lage ist elastisch zu einer im wesentlichen geraden Konfiguration deformiert zu werden, und so an das obere Ende (125A) des Kupplungsgliedes (110A) befestigt zu werden, daß das zweite Ende (145A) jedes Widerhakens (115A) wesentlich von dem Kupplungsglied (110A) verschoben ist, wenn der Widerhaken (115A) in seinem normalen entspannten Zustand ist, aber in der Lage ist mit dem Kupplungsglied (110A) ausgerichtet zu werden, wenn der Widerhaken (115A) zu einer im wesentlichen geraden Länge deformiert ist; und

(c) ein Befestigungsmittel (135A) zum Befestigen eines Abschnittes der Länge des Nahtmaterials (405A) zu dem Kupplungsglied (110A); und

ein Installationswerkzeug (605), das aufweist:

ein verlängertes Glied (610) mit einer zweiten longitudinalen Achse, einem ersten Ende, einem zweiten Ende (620), und einem Schlitz (635), der sich von dem zweiten Ende zu dem ersten Ende hin erstreckt, wobei das verlängerte Glied (610) einen axialen Hohlraum (615) definiert, der sich in das zweite Ende (620) erstreckt;

wobei das System dadurch gekennzeichnet ist, daß

(i) in dem Nahtmaterialanker (105A) das Kupplungsglied (110A) einen unteren Abschnitt (110A), der sich nach oben von dem unteren Ende (120A) erstreckt, einen reduzierten oberen Abschnitt (112A), der sich nach unten von dem oberen Ende (125A) erstreckt, und eine nach oben zeigende Schulter (113A) definiert, die an der Kreuzung des oberen Abschnitts (105A) und des unteren Abschnittes (111A) ausgebildet ist, und

(ii) in dem Installationswerkzeug der axiale Hohlraum größenordnungsmäßig so ausgelegt ist, um mindestens den reduzierten oberen Abschnitt des Kupplungsgliedes aufzunehmen, wobei das verlängerte Glied ferner ein Stoppmittel umfaßt, um zu verhindern, daß der Nahtmaterialanker in einer ersten axialen Richtung relativ zu dem verlängerten Glied sich bewegt, wenn der reduzierte obere Abschnitt in dem axialen Hohlraum aufgenommen ist, und der Schlitz größenordnungsmäßig so ausgelegt ist, um den Widerhaken in sowohl der entspannten als auch der gespannten Konfigurationen aufzunehmen, wenn der reduzierte obere Abschnitt des Kupplungsgliedes in dem axialen Hohlraum aufgenommen ist.

10. System gemäß Anspruch 9 weiterhin dadurch gekennzeichnet, daß das Stoppglied eine Oberfläche (620) aufweist, die mit dem zweiten Ende des verlängerten Gliedes verbunden ist, wobei die Oberfläche konfiguriert ist, mit der Schulter des Kupplungsgliedes in Eingriff zu sein, wenn der reduzierte obere Abschnitt des Kupplungsgliedes in dem axialen Hohlraum aufgenommen ist.

Revendications

1. Ancrage de suture (105A) pour ancrer une portion d'une longueur de suture (405A) dans un os, l'ancrage de suture comprenant :

a) un élément d'accouplement (110A) ayant un axe longitudinal, une extrémité inférieure (120A) et une extrémité supérieure (125A);

b) au moins une barbe (115A), chaque barbe ayant une première extrémité (140A) et une deuxième extrémité (145A), étant incurvée dans son état normal non contraint, étant susceptible d'être élastiquement déformée pour prendre une configuration pratiquement rectiligne, et étant fixée sur l'extrémité supérieure (125A) de l'élément d'accouplement (110A), de telle sorte que la deuxième extrémité (145A) de chaque barbe (115A) est pratiquement déplacée par rapport à l'élément d'accouplement (110A) lorsque la barbe (115A) est dans son état normal non contraint, mais est capable d'être alignée avec l'élément d'accouplement (110A) lorsque la barbe (115A) est déformée pour prendre une configuration pratiquement rectiligne; et

c) des moyens de fixation (135A) pour fixer une portion de la longueur de suture (405A) sur l'élément d'accouplement (110A),

l'ancrage de suture (105A) étant caractérisé en ce que l'élément d'accouplement (110A) définit une portion inférieure (110A) s'étendant vers le haut depuis l'extrémité inférieure (120A), une portion supérieure de section réduite (112A) s'étendant vers le bas depuis l'extrémité supérieure (125A) et un épaulement regardant vers le haut (113A) formé à la jonction de la portion supérieure (112A) et de la portion inférieure (111A).

2. Ancrage de suture selon la revendication 1, caractérisé en ce que la(les) barbe(s) (115A) est(sont) en un alliage de nickel et de titane.

3. Ancrage de structure selon la revendication 1 ou la revendication 2, caractérisé en ce que les moyens de fixation (135A) comprennent un trou s'étendant transversalement à travers l'élément d'accouplement (110A);

4. Ancrage de suture selon la revendication 3, caractérisé en ce que ce trou s'étend en faisant un angle aigu par rapport à l'axe longitudinal de l'élément d'accouplement (110A).

5. Ancrage de suture selon la revendication 3 ou la revendication 4, caractérisé en ce que le trou est situé entre l'extrémité supérieure et l'extrémité inférieure de l'élément d'accouplement (110A).

6. Ancrage de suture selon l'une quelconque des revendications 3 à 5, caractérisé en ce que le trou s'étend à travers l'extrémité inférieure de l'élément d'accouplement (110A).

7. Ancrage de suture selon la revendication 6, dans lequel l'extrémité inférieure de l'élément d'accouplement est disposée en faisant un angle aigu par rapport à l'axe longitudinal.

8. Ensemble de suture (405A) et d'ancrage de suture (105A) pour fixer des objets sur un os, cet ensemble de suture et d'ancrage de suture comprenant :

a) une suture (405A), ayant une première extrémité et une deuxième extrémité;

b) un élément d'accouplement (110A) ayant un axe longitudinal, une extrémité inférieure (120A) et une extrémité supérieure (125A);

c) au moins une barbe (115A), chaque barbe ayant une première extrémité (140A) et une deuxième extrémité (145A), étant incurvée dans son état normal non contraint, étant susceptible d'être élastiquement déformée pour prendre une configuration pratiquement rectiligne, et étant fixée sur l'extrémité supérieure (125A) de l'élément d'accouplement (110A), de telle sorte que la deuxième extrémité (145A) de chaque barbe (115A) est pratiquement déplacée par rapport à l'élément d'accouplement (110A) lorsque la barbe (115A) est dans son état normal non contraint, mais est susceptible d'être alignée avec l'élément d'accouplement (110A) lorsque la barbe (115A) est déformée pour prendre une configuration pratiquement rectiligne;

dans lequel une portion de la suture (405A) est fixée sur l'élément d'accouplement (110A) de telle sorte qu'au moins une extrémité de la suture est libre pour être utilisée dans la fixation d'objets sur un os lorsque l'ensemble de suture et d'ancrage de suture est ancré dans l'os;

l'ancrage de suture (105A) étant caractérisé en ce que l'élément d'accouplement (110A) définit une portion inférieure (111A) s'étendant vers le haut depuis l'extrémité inférieure (120A), une portion supérieure de section réduite (112A) s'étendant vers le bas depuis l'extrémité supérieure (125A) et un épaulement regardant vers le haut (113A) formé à la jonction de la portion supérieure (112A) et de la portion inférieure (111A).

9. Système pour fixer des objets sur un os, le système comprenant :
un ancrage de suture (105A) comprenant :
a) un élément d'accouplement (110A) ayant un premier axe longitudinal, une extrémité inférieure (120A) et une extrémité supérieure (125A);
b) au moins une barbe (115A), chaque barbe ayant une première extrémité (140A) et une deuxième extrémité (145A), étant incurvée dans son état normal non contraint, étant susceptible d'être élastiquement déformée pour prendre une configuration pratiquement rectiligne, et étant fixée sur l'extrémité supérieure (125A) de l'élément d'accouplement (110A) de telle sorte que la deuxième extrémité (145A) de chaque barbe (115A) est pratiquement déplacée par rapport à l'élément d'accouplement (110A) lorsque la barbe (115A) est dans son état normal non contraint, mais est susceptible d'être alignée avec l'élément d'accouplement (110A) lorsque la barbe (115A) est déformée pour prendre une configuration pratiquement rectiligne; et
c) des moyens de fixation (135A) pour fixer une portion de la longueur de suture (405A) sur l'élément d'accouplement (110A); et
un outil d'installation (605) comprenant :
un élément allongé (610) ayant un deuxième axe longitudinal, une première extrémité, une deuxième extrémité (620) et une fente (635) s'étendant depuis la première extrémité vers la première extrémité, l'élément allongé (610) définissant une cavité axiale (615) s'étendant dans la deuxième extrémité (620), le système étant caractérisé en ce que :
i) dans l'ancrage de suture (105A), l'élément d'accouplement (110A) définit une portion inférieure (111A) s'étendant vers le haut depuis l'extrémité inférieure (120A), une portion supérieure de section réduite (112A) s'étendant vers le bas depuis l'extrémité supérieure (125A), et un épaulement regardant vers le haut (113A) formé à la jonction de la portion supérieure (112A) et de la portion inférieure (111A), et
ii) dans l'outil d'installation, la cavité axiale est dimensionnée pour recevoir au moins la portion supérieure de section réduite de l'élément d'accouplement, l'élément allongé comprend des moyens de butée pour empêcher l'ancrage de suture de se déplacer dans une première direction axiale par rapport à l'élément allongé lorsque la portion supérieure de section réduite est reçue dans la cavité axiale, et la fente est dimensionnée pour recevoir la barbe à la fois dans la configuration non contrainte et dans la configuration contrainte de celle-ci lorsque la portion supérieure de section réduite de l'élément d'accouplement est reçue dans la cavité axiale.

10. Système selon la revendication 9, caractérisé en ce que les moyens de butée comprennent une surface (620) associée à la deuxième extrémité de l'élément allongé, la surface étant configurée pour coopérer avec l'épaulement de l'élément d'accouplement lorsque la portion supérieure de section réduite de l'élément d'accouplement est reçue dans la cavité axiale.

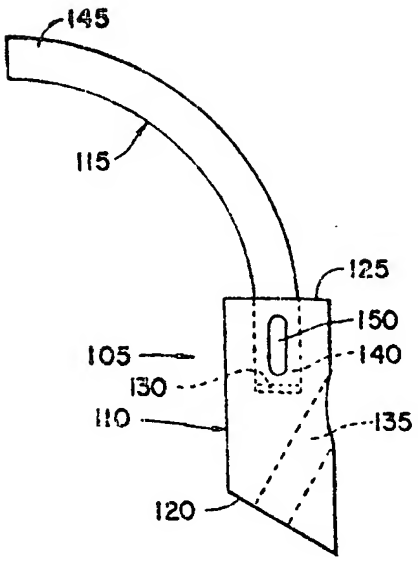


Fig. 1
PRIOR ART

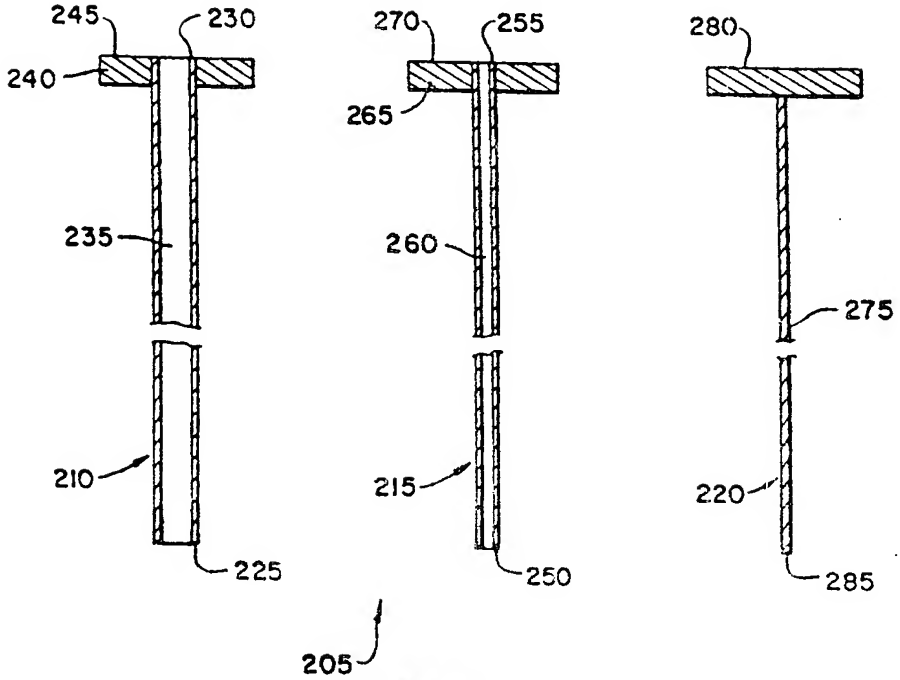


Fig. 2
PRIOR ART

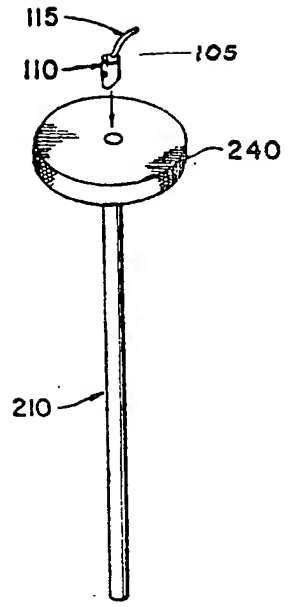


Fig. 3
PRIOR ART

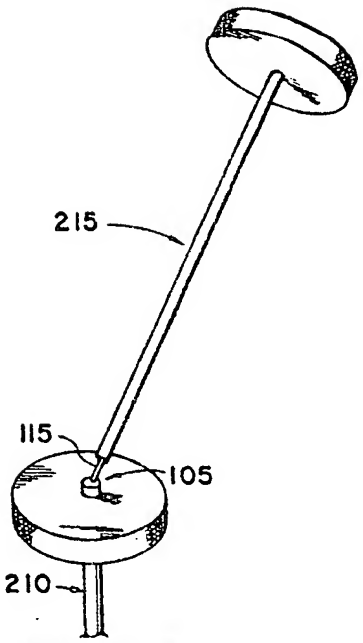


Fig. 4
PRIOR ART

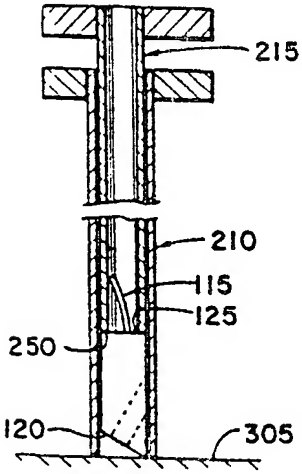


Fig. 5
PRIOR ART

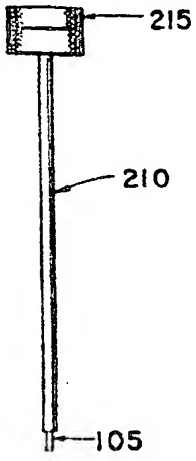


Fig. 6
PRIOR ART

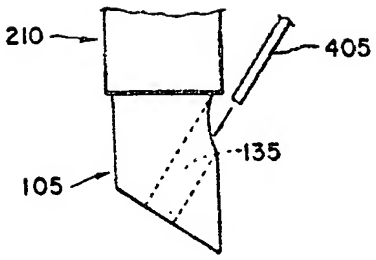


Fig. 7
PRIOR ART

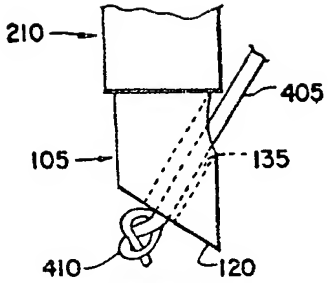


Fig. 8
PRIOR ART

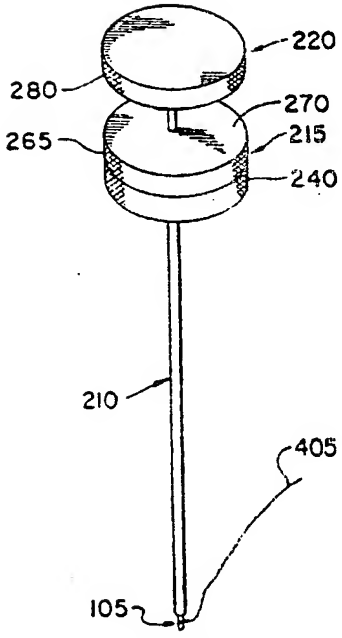


Fig. 9
PRIOR ART

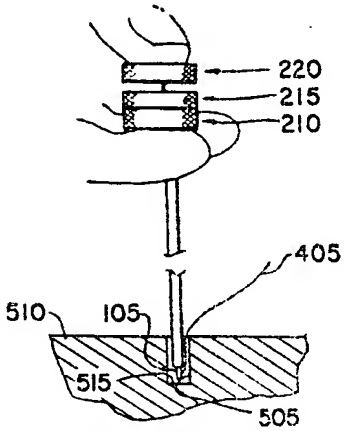


Fig. 10
PRIOR ART

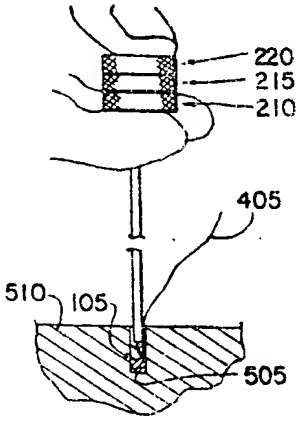


Fig. 11
PRIOR ART

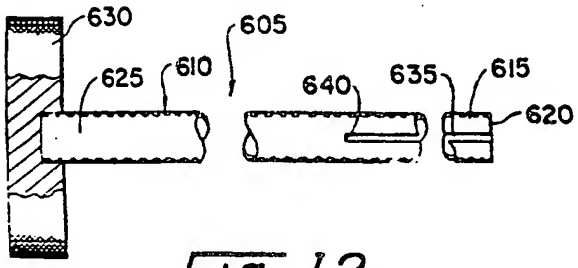


Fig. 12

Fig. 13

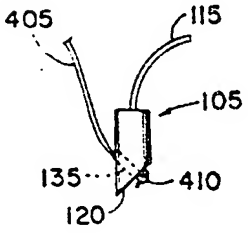


Fig. 14A

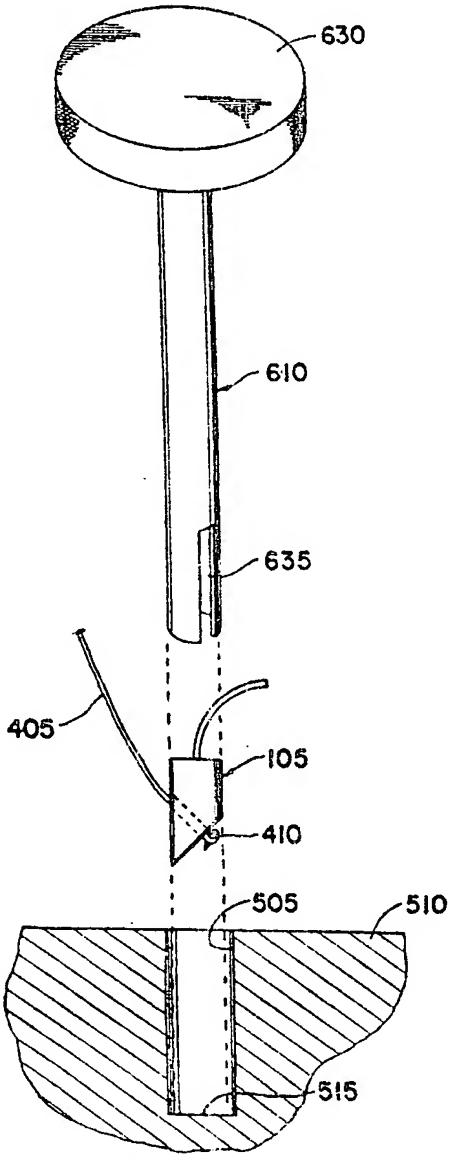


Fig. 14B

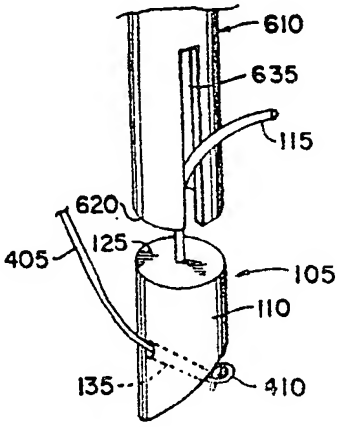


Fig. 15

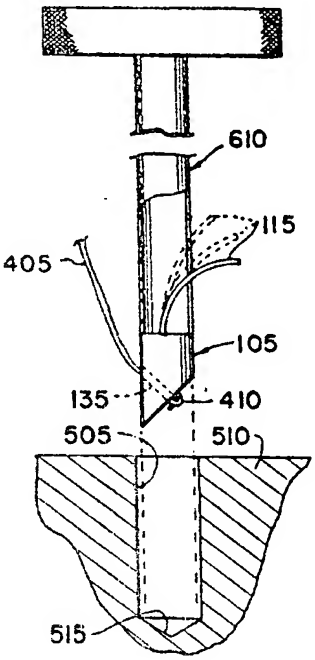


Fig. 16

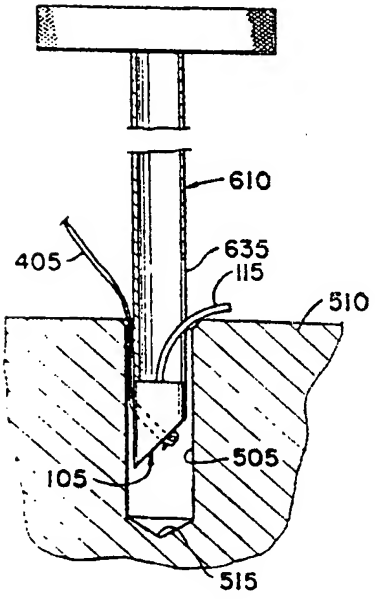


Fig. 17

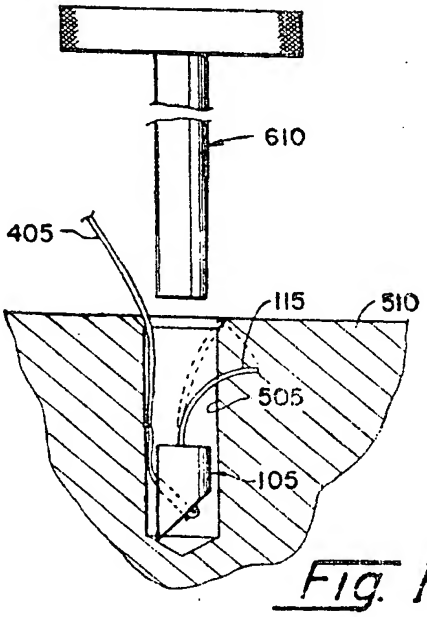


Fig. 18

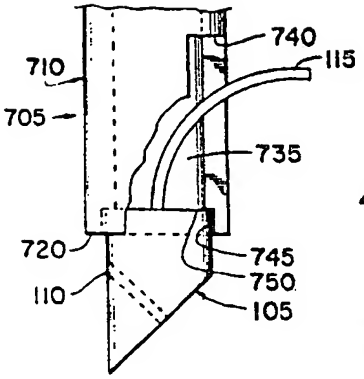


Fig. 20

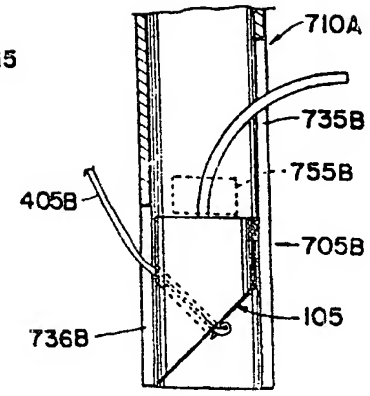


Fig. 21B

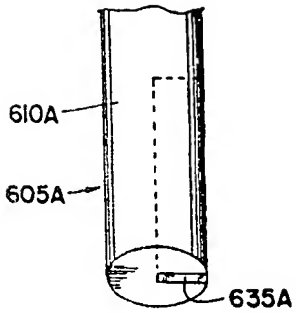


Fig. 19

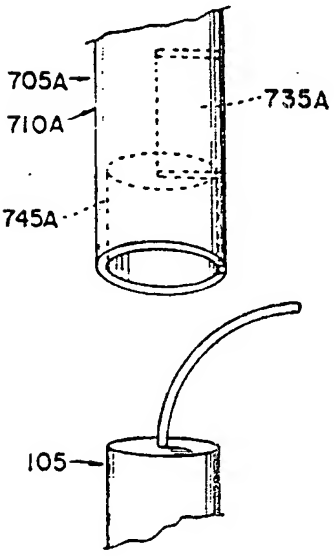


Fig. 21A

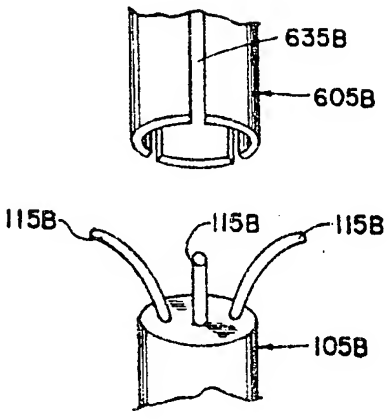


Fig. 22

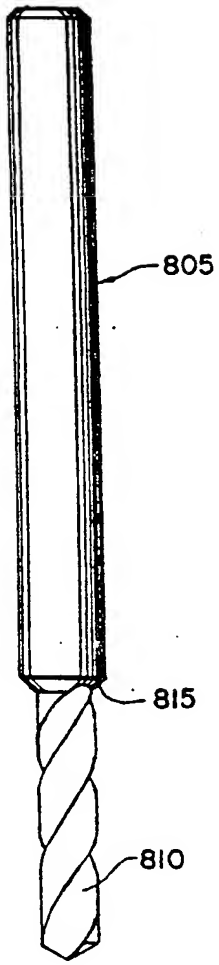


Fig. 23

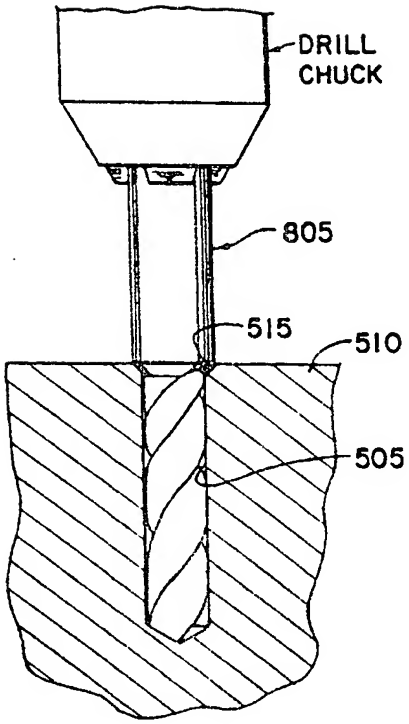
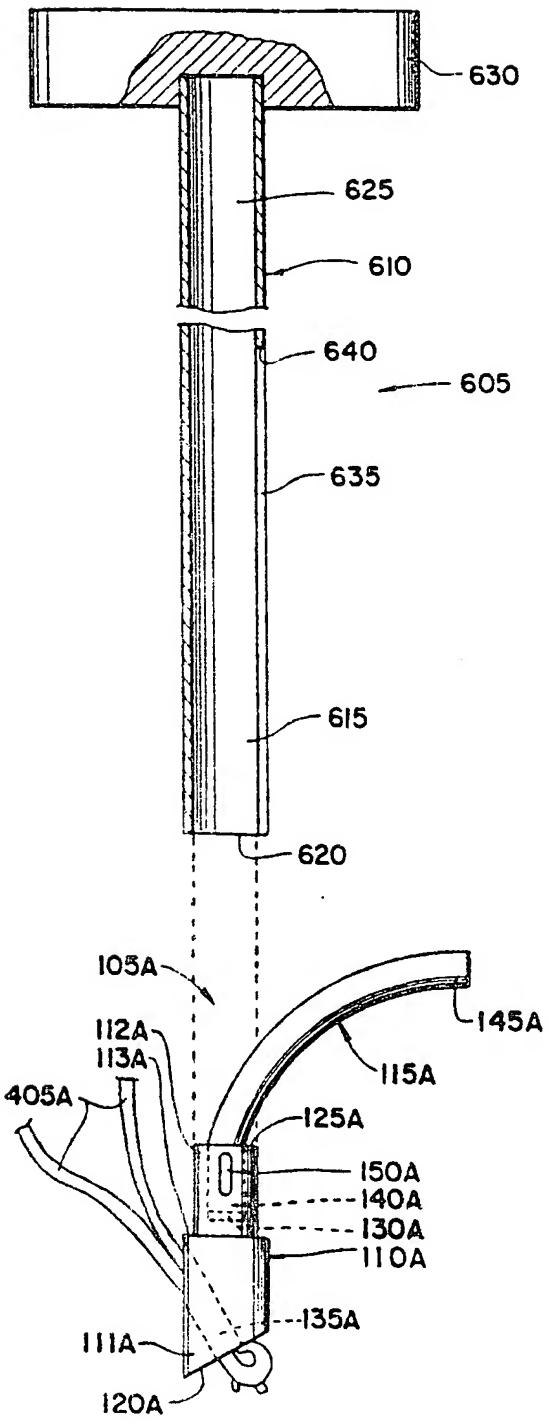


Fig. 24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120A

Fig. 25

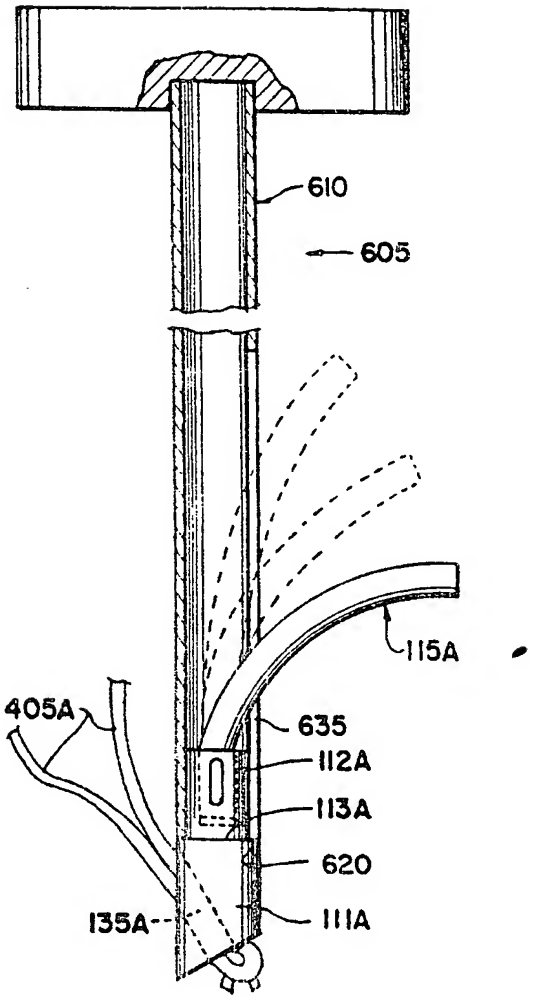

Fig. 26